Pruning Redundancy in Answer Set Optimization Applied to Preventive Maintenance Scheduling

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The current talk is based on a PADL 2023 paper that introduced a pruning approach to increase the efficiency of one industrial application of answer set programming (ASP) [3] and optimization.

Multi-component machines deployed, e.g., in paper and steel industries, have complex physical and functional dependencies between their components. Moreover, the machinery should be kept, by preventive maintenance, constantly in operation with a restricted number of maintenance breaks to maximize production. The multitude of concerns, as briefed above, calls for highly flexible methods for scheduling preventive maintenance actions. Such potential is offered by logic-based methods supporting optimization, including *constraint optimization problems* (COPs) [13, S. 7.4], *mixed-integer programming* (MIP) [13, S. 15.4], *maximum satisfiability* (MaxSAT) [11], and recently even *answer set optimization* (ASO) [14]. Since answer set programming is known to be well-suited for addressing various scheduling and resource allocation problems [2, 5, 7, 12], this paper continues the development of ASO-based encodings [17] for solving *preventive maintenance scheduling* (PMS) problems.

An abstraction of maintenance costs, called *miscoverage*, has been proposed [17] as a simple objective function for the preventive maintenance scheduling (PMS) of multi-component machines. The minimization of even this function has turned out to be a computationally demanding task. Therefore, it is important to study ways to improve the minimization. The talk rudimentally covers the results of a PADL 2023 paper that contained and evaluated *six constraints* on the miscoverage optimization. These constraints prune away some sub-optimal and otherwise redundant or invalid schedules from the search space.

Originally, the pruning constraints already enabled up to ten-fold speed-ups in scheduling times, thus pushing the frontier of practically solvable PMS problem instances to longer timelines and larger machines. Since PADL 2023, the results of the original work has supported our continued research into deeper understanding and more succinct encoding and decomposition of the miscoverage function using ASP modulo theories such as Difference Logic. Further speed-up benefits from the constraints would possibly be realizable if sums of differences and aggregates of the objective function were adequately captured by the underlying methodology without a large number of atoms or rules, and without a much more expressive framework such as MIP.

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